SIERRA
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Model ISO-3

Video Standard Cameras

Aug 79

Features:

High resolution at low light level: 1200 TV lines at 10^{-2} fc or 1000 TV lines at 10^{-3} fc.

Low lag - 3 to 10% 50 ms after removal of illumination.

Low Input noise - Tube S/N ratio determines performance.

Typically 4nA equivalent input noise current over 30MHz.

Integral cooling - no vacuum or air lines needed.

Automatic Horizontal size corrects for line rate, temperature or line voltage change.

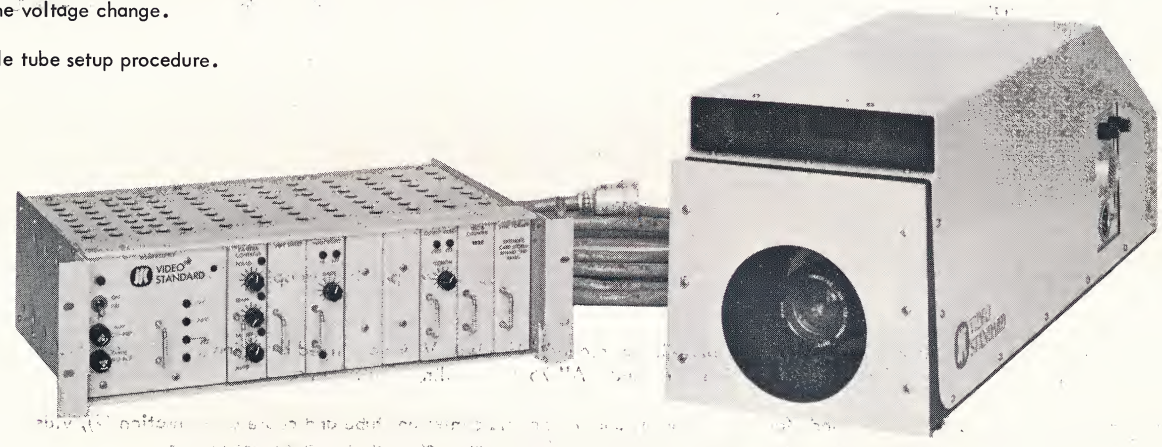
Simple tube setup procedure.

Internal keep alive light to discharge tube in dark.

Adjustable Yoke position for focusing and optical axis alignment.

All operating controls in camera control unit.

All options and features of the Video Standard line apply.



This member of the Video Standard family is designed to make use of the special characteristics of the 3 inch Image Isocon tubes, RCA 4827 and 4828. These are high resolution, high sensitivity to low light levels, low lag, large dynamic range, and high signal to noise ratio. It may also be used with the RCA 4807 which has a fiber optic faceplate which allows it to be used with an image intensifier for increased low light level sensitivity and dynamic range. These Image Isocon tubes give typical resolution of up to 1200 TV lines in the central area at 0.01 footcandles (0.1 lux) or 1000 lines at 0.001 footcandle (0.01 lux). The ISO-3 is designed to exploit these characteristics with its low noise 30 mHz video preamplifier.

The Image Isocon must be operated within a target temperature range of 30 to 50° C. for optimum performance. The ISO-3 is equipped with blowers and filters which allow the camera to operate efficiently in ambient temperatures between 20 and 40° C. and allow safe, if degraded operation in up to 50° C. ambient.

The automatic scan control maintains scan width regardless of line rate and corrects for temperature and line voltage variations. The tube is protected in the event of loss of either horizontal or vertical sweep. All controls, except for those used in initial set up of the tube and deflection assembly are located in the contro unit. The carriage assembly in the head is adjustable longitudinally for focusing and can be rotated around both horizontal and vertical axes to allow perfect alignment of the tube and deflection axis with the optical axis of the lens system. The camera head includes an array of light emitting diodes to discharge the target when the tube is operating in the dark.

The ISO-3 is ideally suited for x-ray inspection where low light levels mean lower radiation dosage. It is also useful in microscopy, document reading or high quality monochrome recording in adverse lighting conditions.

The ISO-3, like the rest of the members of the Video Standard line, uses regulated D.C. supplies for all system voltages, including the tube heater voltage. All major components are on individual plug-in printed circuit modules which may be removed or inserted without power shutdown. All printed circuit boards, including the mother board are glass epoxy material with ground plane plating on critical circuits. The control unit contains an extender card which allows modules to be operated outside the control unit for calibration or trouble shooting. Lens mounts are available for 39mm Leica or 42mm Pentax lenses. The lens cavity in the front of the camera head is 5.1 in. (13.1 cm) diameter by 1.5 in. (11.4 cm) deep. This will accept, with adapter, a wide range of high speed lenses.

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Model ISO-3
Specifications

		Tube Type	4827/4827A	4828/4828A
Resolution and Sensitivity:	Faceplate illuminance (2854°K)		0.001fc (0.01 lux)	0.01fc (0.1 lux)
	Conditions: typical operating values; highlight illumination at knee of transfer characteristics; 525 lines, 2:1, 30 frames per second; 1.4 in (35.5mm) picture diagonal at 4:3 aspect ratio.	Central area	1000 TV lines/ph	1200 TV lines/ph
		Corners	850 TV lines/ph	950 TV lines/ph
Lag:	Percent of initial signal current 50 ms. after illumination is removed		3 - 7%	5 - 10%
Shading:	Percent of maximum highlight signal			
	Black level		1 - 3%	1 - 3%
	White level (10% typ. in central 90%; both types)		15 - 30%	10 - 20%
Signal to Noise Ratio:	Signal to noise-in-signal for highlights at highlight signal current of 6 microamperes (tube characteristics)		20 - 30db	36 - 38db
	Highlight signal to dark current (tube characteristics)		46db typ.	46db typ.
	Highlight signal to rms preamp noise		55db min.	55db min.

Geometry: EIA combined linearity and geometric distortion 1.5% maximum, 1% typical

Scan Rates: Vertical frequency from 15 to 120 Hz; Horizontal frequency from 15 to 40 KHz, 2:1 interlace or sequential scan. Lines/frame (useful range) 256-1536, all EIA rates: (525 to 1225 lines; 60 frames per second, 2:1 interlace.)

Temperature: Operating - optimum 20 - 40° C. Forced air cooling maintains faceplate temperature in optimum ranges/30 to 50° C. Maximum storage 65° C.

Outputs: Video (2) 1.4 V p-p with sync., DC coupled, blanking at ground. H drive, V drive, mixed blanking, composite sync. - 4 V p-p; negative going, DC coupled, base line at ground. All 75 ohm sending-end terminated.

Internal Controls: Misalignment; Photo cathode focus; steering; H and V size and centering; tube and cable compensation (2); video gain preset; aperture correction level; sync level; clamp delay; all sync generation delays and pulse widths.

Front Panel Controls: Electrostatic focus; beam current, target voltage, video gain, pedestal.

Testpoints: ± 12 V, 3.6 V, GND. Focus (G4, G5); Beam (G1); target. Video: Preamp, processed and output.

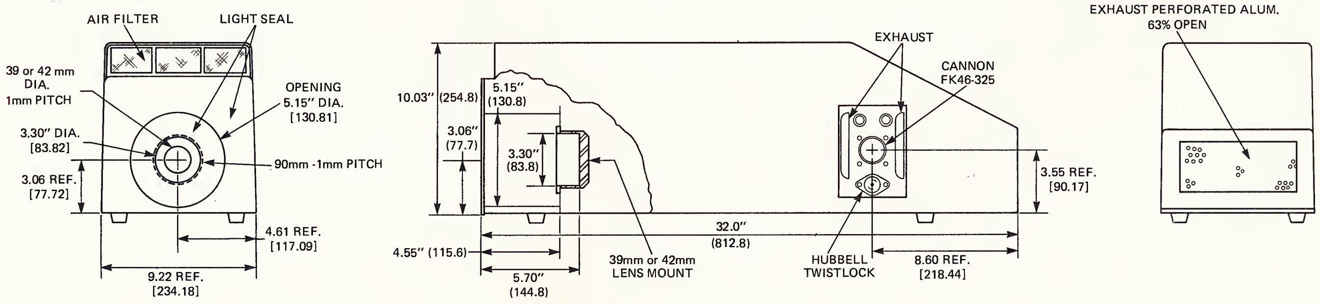
Power: 90 - 140/180-280 VAC 50/400 Hz (by strapping) 100 watts max. 75 watts typ.

Represented By:

DIMENSIONS

	Head	CCU
H	10.03 in. (255mm)	5.25 in. (133mm)
W	9.22 in. (234mm)	19.0 in. (483mm)
D	32.0 in. (813mm)	13.0 in. (330mm)
Wt	43.5 lb. (19.7 kg.)	

Cable: 15 ft. (4.6m) long .88 (22.2mm) diam.
Min. bend radius - 3.5 in. (88.9 cm)
5.5 lb 2.5 kg.



FRONT SIDE REAR

Aug 77

with fiber-optic stage
and consequent
honeycomb effect.

DESIGNING A LLLTV CAMERA

Joseph J. Stafford
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The microchannel plate image intensifier/vidicon combination looks good on paper, but what has to be done to make it work? How does a working model stack up against an ISIT tube or a 3-stage Gen I intensifier/vidicon combination?

The most difficult problems the television camera designer must solve usually involve conflicts between the optimum optical performance of the imaging device and the electronic requirements of the television format.

Of all the low-light-level imaging device combinations available, perhaps the most attractive from both cost and size standpoints is the microchannel plate intensifier/vidicon combination coupled by fiber optics. Although the camera described here is not the first to use that combination, we believe it to be the first to be designed for best performance in instrumentation applications. The imaging devices selected were a 25 mm microchannel inverter tube and a high-resolution 1.5 in. fiber optic faceplate vidicon operated in a deflection assembly with excellent resolution uniformity. These tubes were coupled with a fiber optic cylinder to provide a high voltage standoff and were powered by a supply of our design.

The Microchannel Intensifier

In cross section (see inset), the microchannel intensifier in the "inverter" configuration is identical to a first generation tube to which the microchannel plate has been added. The differences between the two are dramatic, however, due to the characteristics of that plate. Of paramount interest is the tremendous increase in gain. Whereas a single stage "Gen I" tube has typically a luminance gain under white (2870 K) light of 50, the "Gen II" inverter tube gain is in excess of 50,000, roughly equivalent to a 3-stage Gen I assembly and usable at the photon limit.

We were anxious to use the newer device not only because it was smaller than the 3-stage assembly, but because it has less distortion and operates at substantially lower voltage. We chose not to use the microchannel tube in its "wafer" form, which dispenses with the input side focusing cone by using proximity focusing on both sides of the plate, because it has less gain, lower resolution and has a reputation, now somewhat refuted, of having a lifetime too short for commercial applications. Wafer tubes are also much harder to obtain.

Powering Image Intensifiers—The Old and the New

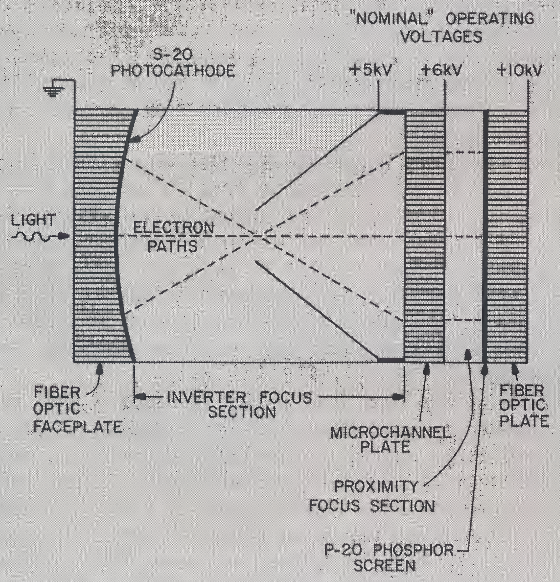
Our prior experience with coupling first generation intensifiers to vidicon tubes provided the basis for our approach to powering the new tube. There are two primary considerations in powering intensifiers: the method of high voltage generation and the selection of a ground point. In Gen I tubes, there are two obvious choices for grounding, the input photocathode and the output phosphor. Experiments with both showed that the grounded input version was far less troublesome, primarily due to scintillation problems when the input is held at the required 45 kilovolts below ground. This is, incidentally, the same polarity used in direct view night scopes.

Grounding the input meant that the output had to be up to 45 kV above ground. In a TV camera it is the output, of course, that is coupled to the vidicon faceplate, which operates near ground. Further, due to the tendency for high voltage to produce holes through fiber optic plates, it is necessary to assure that any given fiber optic plate in the stack never be subjected to both high voltage and high vacuum stresses simultaneously.

Isolating the two devices by a transfer lens is an easy solution but suffers from poor optical efficiency. More efficient, and also more difficult, is the insertion of a fiber optic standoff cylinder between the intensifier output and the vidicon input to take the voltage stress. The difficulties arise primarily from the need to maintain two tight couplings between fiber optic surfaces while allowing quick dismantling of the tube assembly for replacement and experimentation. The final version uses a vidicon with a clamp ring cemented to the glass envelope behind the target ring and a low-pressure clamp mechanism to hold the fiber optic cylinder in place. Microscope immersion oil, with an index matching that of the fibers, is used between the plates. The final assembly is rugged enough to be transported outside of the camera without decoupling and will recover from minor decoupling due to excessive stress overnight.

The experiences of others, primarily in direct view devices, indicate that the Gen II tubes produce minimum noise if one side of the microchannel plate (MCP) is grounded. Since good evidence exists supporting both input and output side grounding, we simply chose the easier to implement and grounded the input. The tube manufacturers also seem to prefer this mode.

Why the grounded input mode is easier to implement can be seen in **Fig. 1**. In order to stabilize brightness and maintain high resolution, the voltage between the MCP output and the output phosphor screen should be kept constant, as must the ratio between the MCP-focus electrode and focus electrode photocathode voltages. However, the best way to change the gain of the device is to vary the MCP input-output voltage. If we accomplish this by varying the input voltage, then a slaved supply that maintains the focus electrode ratio within 1% is necessary. On the other hand, varying



How Do Gen II Intensifiers Work?

Electrons ejected from the photocathode by incoming light are focused on the input of the microchannel plate by a conventional inverting cone. The accelerating voltage inputs sufficient energy to these electrons to generate secondary electrons inside the holes in the microchannel plate. The electron bundles resulting from repeated striking of the walls exit from the holes to be proximity focused on the output phosphor. Because only a limited amount of wall current is available inside the holes, the output brightness is also limited. (The "typical" operating voltages shown in the drawing are generic in nature.)

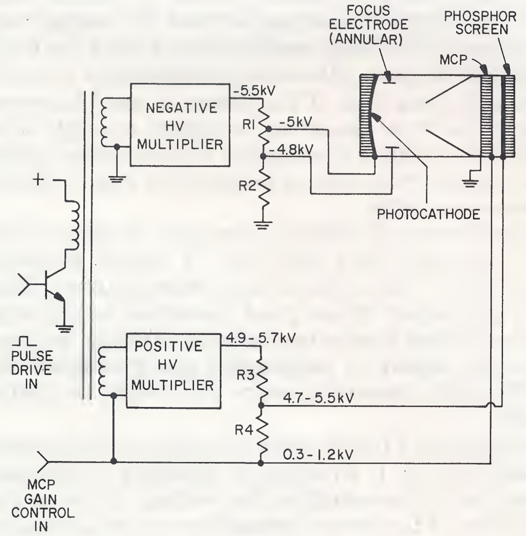


Fig. 1. MCP gain control in the intensifier is powered by a pair of diode-capacitor multipliers. Resistors R1 through R4 are selected to provide the proper voltage ratios.

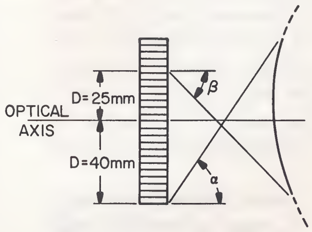


Fig. 2. Larger photocathodes show more blemishes and higher background illumination because of the larger angle marginal rays make with the normal ($<\alpha > <\beta$).

Fig. 3. Photo of x-ray of a human hip shows "chicken wire" effect.

TABLE 1 Image Tube Comparisons

Tube	25 mm Gen II w/1.5″ Vidicon	40 mm Gen I w/1.5″ Vidicon	40 mm ISIT w/1.5″ Target
Physical			
Overall length (inches)	10.5	16	16.5
Max. Diameter (inches)	2.2	3.8	3.8
Optical			
Photocathode Diameter (mm)	25	40	40
Number of f.o. Plates	5 (incl. MCP)	8	3
Maximum photon-limited resolution (100% contrast) (TVL/ph)	700	600	600
Maximum resolution at 10^{-4} lux (TVL/ph)	800	700	800
Distortion (EIA method) Central Circle	1%	4%	2%
Electrical			
Maximum Voltage (kV)	+5, −5	45	−21
Visual			
Scene Dynamic Range (50:1 output variation)	100:1	100:1	50:1
Point Overload Tolerance	Excellent	Fair	Poor
Lag (3rd field) at 10^{-4} lux	25%	30%	10%
Noise	Good	Good	Fair
Burn Resistance	Good	Poor	Excellent
Gross exposure overload tolerance	Good	Good	Poor
Cost			
Image Tube Price (lowest=1)	2	1	3
Price Trend	Down	Up	Stable

the output requires only that the phosphor screen voltage be floated on the MCP output voltage.

The power supplies themselves are straightforward. To provide most of the high voltage, a switching supply is used. To avoid interference in the image, this supply is pulsed synchronously with the horizontal deflection. Additionally, tilt in the video amplitude along the scan lines resulting from the pulses interfering with the clamp is eliminated by allowing pulsing only during vertical blanking. That means larger transformers and multipliers than would be needed for continuous-duty supplies, but at starlight levels the noise improvement outweighs the increased volume.

It is then an easy matter to provide an adjustable MCP voltage by floating the phosphor screen supply. We used a stock power supply normally used to generate the vidicon mesh voltage, which can be programmed from 0 to 1.2 kV by an external voltage source.

Optical Considerations

More lenses are available for smaller image formats than larger ones, so any reduction in format size increases the lens selection. As will be seen, to match the performance of the 25 mm Gen II intensifier/1.5 in. vidicon combination, either a 40 mm ISIT or a 40 mm 3-stage Gen I intensifier coupled through a fiber optic reducing cone to a 1.5 in. vidicon is necessary. Both of these could use standard 35 mm SLR camera optics, but the contrast and corner resolution would be poorer than can be realized with the 25 mm format. The rays that are nearly parallel to the fiber optic surface contribute most of the leakage between fibers and emphasize dark blemishes and surface imperfections. Since more of these rays are encountered at larger diameters, smaller faceplates show less degradation (**Fig. 2**). Additional edge degradation results from the use of a larger portion of the lens format.

Because of the wide variety of both standard and custom optics available, we designed the tube carriage to incorporate a 1.5 in. back focal length adjustment range. The front of the tube is double baffled to eliminate stray light problems and permit operations with the covers off.

Fig. 4a. Horizontal square wave response (525 Lines, 30 frames per second, 2:1 interlace).

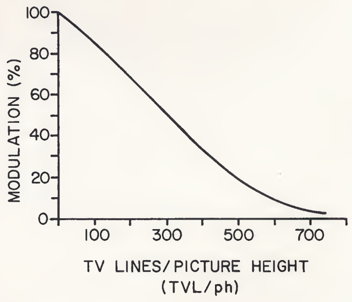
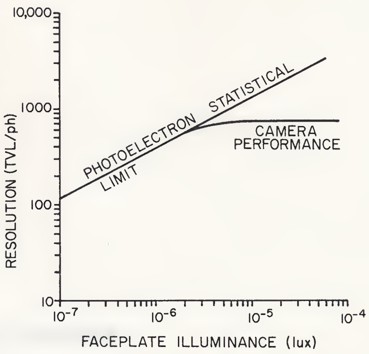


Fig. 4b. Resolution vs. illuminance (2870 K) at 100% contrast and 15 MHz bandwidth.



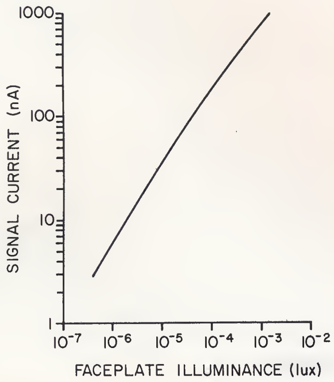


Fig. 4c. Signal current vs. illuminance (vidicon dark current is 20 nA).

Performance

The big question is, of course: "How well does it work?" Consider the synergism of the image tube combination.

- The brightness of the intensifier limits at approximately the same point as the vidicon tube begins to overload.
- The vidicon tube has just enough image retention to smooth out the photon noise in low level scenes and also to minimize the noise contribution of the microchannel plate.
- The 2/3 power gamma of the vidicon brings out detail in the dark areas of the scene while the MCP clips off the bright white points.
- The intensifier has a wide enough control range and sufficient gain to allow the vidicon to be operated at a fixed target voltage low enough to make dark current inconsequential.
- The Sb_2S_3 photoconductor is an excellent match for the P20 phosphor.
- The shading inherent in inverter tubes can be compensated by providing sensitivity modulation at the vidicon cathode.
- The intensifier resolution limit is 28 lp/mm, while the vidicon limits at 50 lp/mm. This is high enough to reproduce the intensifier image but low enough to minimize transmission of fine intensifier defects.

This compatibility makes the tube compare well with the 40 mm 3-stage Gen I intensifier on a vidicon and the 40 mm ISIT (**Table 1**). In fact, it was the price comparison with the ISIT and the performance comparison with the Gen I tube that convinced us to use the Gen II device originally.

Current commercial grade Gen II tubes do have one defect that may be important in some applications. Due to the construction techniques of MCP manufacture, many tubes show a visible "chicken wire" structure (**Fig. 3**). This is usually minimized when the MCP voltage is maximum, but does not always disappear completely. Tubes that do not have this artifact can be selected.

The detailed performance curves in **Fig. 4** show that this combination does indeed perform well. For best performance we offer these suggestions:

- Operate the Gen II intensifier at light levels that just begin to show photon noise to produce maximum contrast.
- Protect the input photocathode from long exposures in excess of 10^{-1} lux to minimize ion burning.
- Keep the vidicon target voltage low to minimize dark current, lag, and burn-in.

Improvements

There are improvements to be made both in image tube quality and in camera performance. Our next step (if we can find a likely prospect) may be to couple the Gen II tube to a fiber optic revision of the new high-resolution Plumbicon® to allow fast dynamic imaging at low light levels.

Now, if only that tube had an ACT gun . . .

References

1. RCA Electro-Optics Handbook IOH-11, 1974.
2. Taylor, D. G., and Schagen, P., "The Application of Channel Image Intensifiers to Low-Light-Level Television", *Advances in Electronics and Electron Physics*, Vol. 33, Pp. 945 Ff.

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Preliminary Data
MODEL IVG 1.5/25
Low Light Level TV Camera
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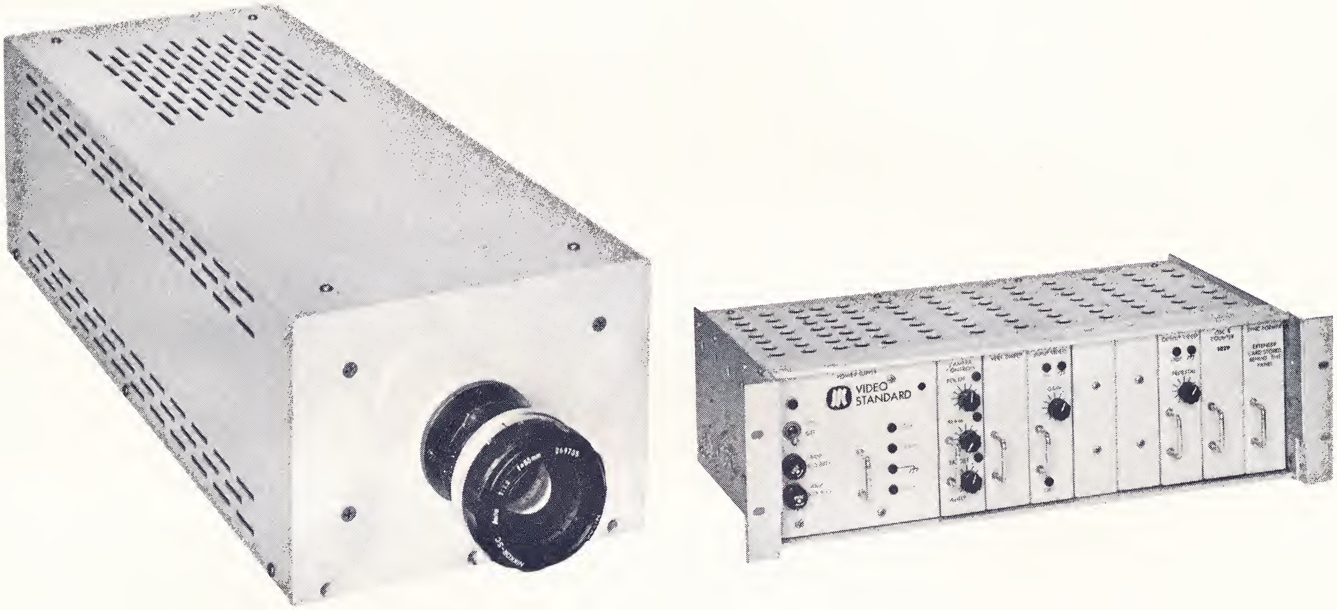

Designing a Low Light Level Television Camera
Joseph J. Stafford
David Gilblom

This reprint of an article appearing in the August 76 issue of Electro Optical Systems Design describes the latest addition to the Video Standard line of cameras manufactured by Sierra Scientific Corporation. This is the IVG1.5/25, an intensified Vidicon camera using a 25mm, second generation, micro channel plate intensifier and a 1.5 inch high resolution vidicon coupled by a fiber optics isolator. This design offers starlight operation with excellent resolution at moderate cost and greatly reduced operating voltages. As a member of the Video Standard line, it uses the same camera control unit with its capabilities for line rate variations; video processing, etc.

For further details or for information about adaptations of this camera for special applications, different image tube types, etc., please contact the authors at Sierra Scientific Corporation, 2189 Leghorn Street, Mountain View, California, 94043, (415) 969-9315.